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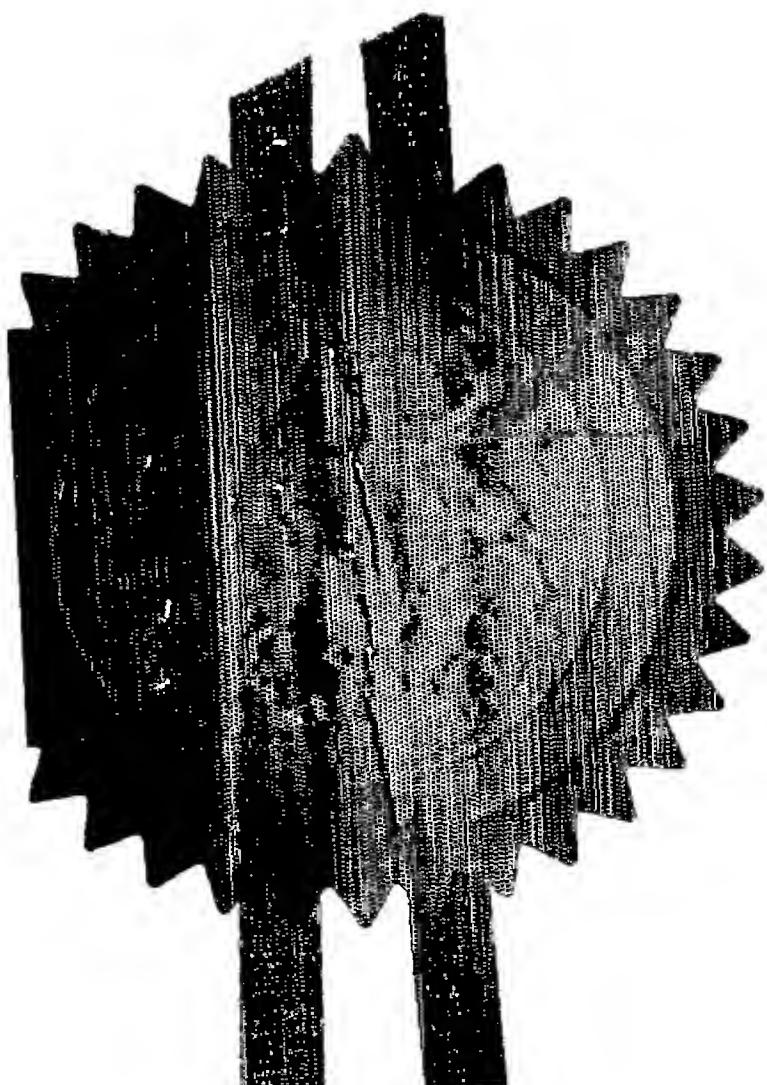
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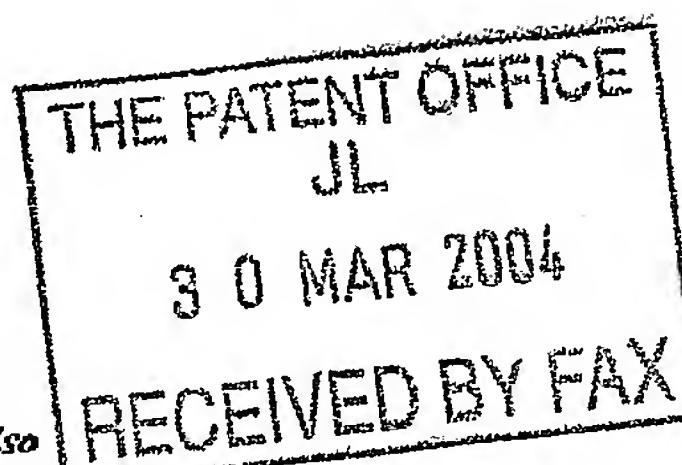
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1. Your reference

47/64748GB

2. Patent application number  
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30 MAR 2004

3. Full name, address and postcode of the or of  
each applicant (underline all surnames)

Stolt Offshore Limited  
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Patents ADP number (if you know it)

If the applicant is a corporate body, give the  
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GB

4. Title of the invention

Method and Apparatus For laying Elongate Articles

5. Name of your agent (if you have one)

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Priority application  
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Description 13 ✓

Claim(s)

Abstract

Drawings(s) 5 Only

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Priority documents \*

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Statement of inventorship and right to grant of a patent (Patents Form 7/77)

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Signature(s) FITZPATRICKS

Date 30 March 2004

12. Name, daytime telephone number and email address, if any, of person to contact in the United Kingdom

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0141 306 9000

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**DUPLICATE****METHOD AND APPARATUS FOR LAYING ELONGATE ARTICLES****INTRODUCTION**

- 5 The present invention relates to methods and apparatuses for laying elongate articles at sea, and especially to pipe laying vessels.

Various methods and apparatus are known for laying continuous steel pipe (known as rigid pipe) from a vessel at the sea surface onto the seabed. The pipeline may be welded 10 on board from sections, as disclosed in US05975802 (Willis/Stolt), or may be laid from a pre-loaded reel, as in US 4917540 (Recalde/Santa Fe). For deep water, a steep angle of departure of the pipeline into the water must be arranged, using track tensioners, or other tensioning means such as movable clamps, in order to align with the natural catenary curve of the suspended pipeline. Bending of the pipe under this very high 15 tension is liable to cause damage.

In addition to rigid pipes, flexible pipeline and cables may be laid from a vessel, typical from a coil in a carousel located below deck. Conventionally, the flexible pipe follows a horizontal path and is diverted over board via a sheave (wheel), to protect it against 20 excessive bending. Vertical lay arrangements are known for flexible pipe, for example from EP 0717222 A (Stolt) and WO 91/15699 A (Coflexip Stena Offshore), but the horizontal path has advantages. In any case, generally vessels are specialised to one type of product (rigid or flexible), or are provided with separate apparatus for each type 25 of product. This requires a larger vessel, and of course a greater cost of equipment.

25

One vessel advertising capacity to handle both rigid and flexible product in a single apparatus is Technip/Coflexip 'Deep Blue', described in WO 00/66922 A1. However, this is a very large capacity and costly vessel, and therefore not necessarily adapted to all types of operation. Moreover the tensioners are fixed in vertical orientation which is 30 not necessary or optimal for handling the flexible product in particular.

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The invention aims to provide cost-effective methods and apparatus whereby a single vessel can be adapted readily between a configuration suitable to lay rigid pipe along a vertical path, and a configuration suitable for laying flexible pipe along a substantially horizontal path.

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In a first aspect of the invention, there is provided a dual-mode apparatus for handling elongate articles, the apparatus comprising tensioning means mounted on a structure tilttable between upright and horizontal states.

10

The tilttable structure in its upright state may carry a radius controller and straightener for conditioning rigid product, at a position upstream of the tensioning means.

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The radius controller and/or straightener may be provided at least partially in the form of modules to be removed when the structure is in the horizontal state. This alleviates space constraints and allows use of a smaller vessel.

20

The apparatus may further comprise overboarding means for receiving flexible product from the tensioning means when the structure is in its horizontal state. The overboarding means may comprise sheave.

25

The overboarding means may be provided at least partially in the form of a module to be removed when the structure is in the upright state. Again, a compact apparatus is facilitated, and particularly avoiding congestion in the region where the pipe is launched from the vessel into the water.

30

The tilttable structure may be connected to the vessel by a single pivot.

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The tilttable structure may be connected to the vessel so as to retract bodily away from a launch point of the product in order to reach said horizontal state. This may be achieved as part of a single operation with lowering the structure about single pivot by placing the pivot point away from an axis of the tilttable structure.

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The tiltable structure may alternatively be connected to the vessel by one or more arms pivotally connected at one end to the tiltable structure and at another end to the vessel. This can permit independent modes of movement for (i) lowering the structure from upright to horizontal and (ii) retracting the structure away from a launch point of the  
5 product, with various advantages. Alternative arrangements to support and reconfigure the structure are also possible.

\* These and further features and advantages of the invention will be understood by the skilled reader from a consideration of the embodiments described below.

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**BRIEF DESCRIPTION OF THE DRAWINGS**

Embodiments of the invention will now be described, by way of example only, by reference to the accompanying drawings, in which:

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Figure 1 presents various general arrangement (GA) views of a pipe laying vessel incorporating novel pipe handling apparatus according to a first embodiment of the invention;

10

Figure 2 is an enlarged partial side view of the vessel, showing the novel pipe handling apparatus in an upright mode;

Figure 3 is an enlarged partial side view of the vessel, showing the novel pipe handling apparatus in a horizontal mode;

15

Figure 4 is an enlarged partial plan view of the vessel corresponding to the side view of Figure 3;

Figure 5 is an enlarged partial plan view of the vessel corresponding to Figure 4 but at a lower deck level;

Figure 6 (a) and (b) are enlarged partial side views of an apparatus according to a second embodiment of the invention, in upright and horizontal mode respectively; and

20 25 Figure 7 illustrates steps (a) to (h) in the lowering and retraction of the apparatus of the second embodiment between vertical and horizontal modes.

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**DETAILED DESCRIPTION OF THE EMBODIMENTS****General Arrangement (First Embodiment)**

5 Referring to the general arrangement (GA) view shown in Figure 1, a pipe laying vessel is shown in two different modes of operation in a partially cut-away side view in parts (a) and (b) of the drawing. Part (c) is a plan view corresponding to side view (b), in particular at a shelter deck level, being the highest deck on which most operations will be conducted. Part (b) shows additional features at a main deck level, below the shelter 10 deck.

Figures 2, 3, 4 and 5 are enlarged views of the stern portion of the vessel, corresponding respectively to views (a), (b), (c) and (d) of Figure 1. Accordingly, the 15 following description applies to all of the Figures 1 to 5, in which the reader is invited to look at Figures 2-5 for more detail.

The vessel naturally comprises a hull 100 with a superstructure 102, located in this case forward of a larger working area. The vessel has various thrusters 104 to provide dynamic positioning (position holding) during pipe laying operations. The novel pipe 20 handling apparatus to be described in detail below is configurable for the laying of rigid continuous pipe or alternatively flexible pipe. Such conduits and other elongate articles such as cables and umbilicals are known to the skilled reader. The reader will also appreciate that the arrangements required for laying these different types of articles generally mean that different equipment is used for the two purposes.

25

In the present example, a large reel 106 is provided for continuous rigid pipe and oriented with a horizontal axis. An extended spooling arm 108 is also provided. As an alternative or supplement to the reel 106, means may be provided on deck for welding pipeline from discrete sections, in a manner well known *per se*. For the storage and 30 dispensing of flexible product, on the other hand, a carousel 110 located below deck level is provided. A second storage space 112 is provided, for cable and the like.

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Various ancillary equipment in the form of winches, ROV garaging, and particularly cranes 120, 122, 124 and 126 is shown. The aft cranes 120, 124 are removed in most of the drawings, to allow a clear view of the apparatus 200. As will be appreciated by the skilled reader, these cranes play an important part in the pipe laying operations, 5 particularly where end terminations or mid-line modules must be included, as well as in other hoisting operations of a more general nature. The outer cranes 120 and 124 are shown in alternative working positions, for illustration only. One such module 130 is shown in Figure 2, for the sake of example, which would be suspended from crane 120 (not shown in Figure 2).

10

At the main deck level (Figure 1(d) and Figure 5 show this most clearly), a retractable working platform 132 is provided for handling such modules and connecting them to suspended pipe, for example. This platform is associated with a hold-off clamp 133 in a known manner. Similarly, an A-frame 134 is mounted on a raised working deck 136 15 for further versatility in handling objects other than continuous pipe cable, this being best seen in Figures 3 and 4.

20

At the stern of the vessel is mounted the novel pipe handling apparatus 200, which is operable in different orientations, according to whether rigid or flexible pipe is being laid. Apparatus 200 comprises primarily a tiltable support structure 202 and a tensioning means in the form of a track-type tensioner 204 which can pay out pipe under considerable tension. The tensioner in this example comprises four rolling tracks arranged about the axis of the product being handled, which can be pressed together by hydraulic rams to squeeze the pipe, in a known manner. The tensioner 204 is shown 25 always with its tracks open, in the accompanying drawings.

30

In Figures 1(a) and 2, the apparatus 200 is shown in an upright position adapted particularly for the laying of continuous rigid product. The structure 202 is shown both completely vertical and with the same structure in an off-vertical position shown with label 202'. In Figures 1(b), 1(c), 3 and 4, the apparatus 200 is shown in an alternative configuration, with the structure 202 and tensioner 204 lying horizontally for use in

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laying flexible product. Further differences between these configurations will be described in more detail below.

Also surrounding the tiltable structure 202 is an extension of working deck 136,  
5 supported on a fixed structure. This is not shown, for clarity, in Figures 1 to 5, but a similar fixed structure will be seen in detail in the example of Figures 6 and 7.

#### Upright Configuration for Rigid Pipelay

10

Referring in particular to Figures 1(a) and the enlarged view in Figure 2, it will be seen that additional modules are fitted to the structure 202 to enable it to perform the laying of rigid pipe in the vertical or near-vertical orientation. That is to say, in the present embodiment the equipment specific to rigid pipe laying is provided in modules 208 and  
15 210 and 220 which can be detached to change from the upright mode of operation to the horizontal mode, described further below. Module 208 comprises a straightener 212 of well-known three-track type, a winch 214 and a tiltable working platform 216. Module 208 is also shown separated from the structure at the left hand side of Figure 2. Module 208 also effectively extends the height of the tiltable structure 202. At the top  
20 or upstream end of structure 202 a radius controller 220 is fitted, and module 210 comprises an extension of this. As can be seen at 216' in Figure 2, the platform 216 can rotate to remain horizontal for workers thereon, as the structure 202 moves from its vertical position to an off-vertical position 202'.

25 In operation, continuous rigid product is unreeled from reel 106, via spooling arm 108 to the top of radius controller 220/210 where it is bent, potentially involving plastic deformation, to align with the lay axis and pass through the jaws of straightener 212. It will be noticed that spooling arm 108 reduces the span travelled by the continuous pipe laying between reel 106 and the apparatus 200, as indicated at 230 and 232 in  
30 Figure 1(a). The straightener 212 removes the bending imparted by the reeling and radius controller 220, to supply a substantially straight product into the jaws of the tensioner 204. Tensioner 204 feeds the pipeline slowly down into the sea, while the

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reel 106 unwinds synchronously, with a certain back tension maintained for control and safety. The suspended weight of pipeline when operating at great depth can be very considerable (hundreds of tonnes), and the orientation of the structure 202, and hence tensioner 204, is controlled, together with positioning of the vessel, to ensure that the structure aligns very closely with the natural catenary path of the suspended pipeline.

5 Accordingly, the part of the pipe which is under the heaviest tension is not subject to bending, and is less prone to damage.

It will be noted how the positioning of tensioner 204 on structure 202 allows the

10 pipeline end termination (PLET) or other bulky module 130 to be accommodated in line between the outlet of the tensioner 204 and the retractable working platform 132. Hold-off clamp 133 is used for suspending the pipeline (234 in Figure 2) while this operation is conducted. Tensioner 204 can open to the position shown in the drawings, and winch 214 can be used to assist in manipulating module 130 into line, and for other

15 abandonment and recovery operations.

#### Horizontal Configuration for Flexible Pipe laying

20 Referring now to Figures 1(b) and (c) and to Figures 3 and 4, structure 202 can now be seen in a fully horizontal position, which is convenient for flexible pipe to be laid. In reaching this configuration, tiltable structure 202 has moved about a pivot 236 under control of hydraulic rams or similar jacking means (not shown). The pivot 236 is level with the foot of the structure 202 when upright, but is offset from the line of the

25 structure 202. By this arrangement, the structure 202 not only tilts from vertical to horizontal, but also moves bodily inboard, away from the line where the pipe, cable etc. is desired to enter the sea. This makes room for the overboarding sheave to be mounted to the downstream end of the structure 202.

30 In changing from vertical to horizontal configuration (which can be done at a shore base if necessary), the apparatus 200 has also been modified by the removal of modules 208 and 210, and the replacement of module 220 directly onto the end of structure 202,

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where module 208 was formerly located. Clearance 238 is indicated in Figure 3, where the segment 210 has been removed and stowed elsewhere on the vessel. It will be appreciated that the extended section 210 could be also a permanent part of radius controller 220, if a recess could be provided in the deck to accommodate it, or if space 5 between the deck and structure 202 in its horizontal position were sufficient to accommodate it in any case. However, it is clearly more convenient for it to be removable.

While module 208 including the straightener 212 has been removed from the upstream 10 end of the structure 202, a different module 240 has now been mounted at the downstream end, which comprises primarily an overboarding sheave 242, which is a wheel adapted to support and turn with a flexible pipe (not shown) as it passes from tensioner 204 over the stern of the vessel and into the sea. Using the radius controller 220 and other guiding arms (not shown) it is therefore possible to unload a continuous 15 flexible product from carousel 110, under control of tensioner 204, and pay it over the side without excessive bending or other damaging treatment.

Design Considerations

20

Various considerations arise from the desire to use tensioners for handling both rigid and flexible pipelines and umbilicals. An important consideration for handling flexible pipes (and also coated rigid pipes) is to respect the maximum crush load of each product, whilst achieving the necessary friction to support the weight of suspended 25 pipeline safely. Conventionally, tensioners adapted for handling rigid pipe are much shorter than flexible pipe tensioners, because they can squeeze harder without damaging the pipe and therefore require less contact length to achieve the necessary friction to hold the product. Compared with a normal rigid pipe tensioner, therefore, it will be seen that tensioner 204 in the apparatus 200 has a greater length than would be 30 expected.

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The squeeze pressure and pad design are also important parameters. The hydraulics of the tensioner unit in the novel apparatus will therefore be modified to provide a wider range of squeeze pressures. In particular, it proposed that a dual hydraulic system be used, whereby a number of the squeezing cylinders can be "turned off". This will 5 reduce the overall squeezing pressure without requiring fine adjustment of the hydraulics, and effectively gives a dual range system.

With regard to pad design, a number of pad sets are provided to cover the range of different products. In a preferred embodiment, these are manufactured in two parts. A 10 base piece is bolted to the tensioner track and stays in place for all operations, while an insert fitted with a quick release mechanism can be changed for a different insert relatively quickly. In particular, a number of sets of inserts with different radii and/or pad material will be used to cover the variety of products, while being light and easy to change.

15

Deck layout is also an important factor, in order to meet the requirements of both configurations. The tensioner position in each mode is generally pre-determined by the specification. Accordingly, the tower rotation point 236 must be selected such that the tensioner always ends up in the desired place. Crane location is important to achieve 20 adequate coverage for both types of operation and similarly winch location, lay routes and loadout methodology require consideration.

The apparatus and general arrangement of the vessel presented above and illustrated in the drawings satisfy these various considerations. In particular, in order to perform 25 rigid lay in a vertical configuration and flexible lay in a horizontal configuration, there is provided a tower structure that can operate from 0° to 90° from horizontal. It is attractive to lay flexible products horizontally for operational reasons, including easier access, easier working and a general preference by particular customers.

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Second Embodiment

Figure 6 illustrates an alternative for the apparatus 200, with in particular a different pivoting and jacking mechanism from the apparatus of Figures 1-5. Figure 6(a) shows the apparatus in the upright configuration, while Figure 6 (b) shows it in the horizontal mode. The same reference signs are used for the various components of the second apparatus, but with prefix "6" to distinguish them from the corresponding parts of the apparatus of Figure 1 to 5. Only the differences will be specifically described.

Firstly it will be seen in Figure 6 (a) that the extension of the raised working deck 6136 is visible, and supported below by a fixed structure 6300. Radius controller segments 6220 and 6210 are fitted on top of a removable module 6208, but in this example the winch 6214 is located lower in the module 6208, and it co-operates with a sheave 6302 mounted in the radius controller section 6220. The functions of these elements is the same as in Figure 1, however.

The structure is again moved from upright to horizontal by pivoting about a pivot 6236, and in this example the hydraulic ram 6304 responsible for this movement is shown (in practice two or more rams will be provided and operate in parallel). In this second example, however, the pivot point 6236 is not fixed with respect to the deck, but is moveable. Specifically, pivot 6236 is at the end of an arm 6306, which in turn is connected to the deck at a pivot 6308. Ram 6304 acts not between the structure 202 and the deck, but between the structure 202 and an intermediate point on arm 6306. As will be illustrated with reference to Figure 7 (a) to (h), this allows the same ram 6306 to perform the two actions of pivoting the structure down to horizontal and retracting it inboard to make room for the overboarding sheave 6242, while also separating those actions. This provides more design freedom than the single pivot 236 in the first example. The articulated structure 6202/6306 can be moved using significantly less powerful rams than would be required to move the structure 202 as a unit. Depending on the exact layout, it may also allow the heavy tensioner 6204 and the working deck 6136 to be mounted lower, aiding stability of the vessel overall.

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In Figure 7, steps in the movement of the structure 6202 and associated parts are shown, with all surrounding structure removed for clarity. Steps (a) to (d) describe the lowering of the structure from vertical to horizontal, while steps (e) to (h) show the subsequent process of retraction. Step (a) corresponds to the state of the apparatus shown in Figure 6(a), while step (h) corresponds to the state shown in Figure 6(b).

In all of steps (a) to (d), it should be appreciated that the arm 6306 is pinned somewhere along its length to a part of the fixed structure 6300, so that it maintains a fixed orientation. Pivot 6308 is fixed to the deck, so in this phase of operation pivot 6236 is also fixed with respect to the vessel. In step (a), the structure 6202 is vertical, and indeed is in use for the laying of continuous rigid pipe 6320 under control of the tensioner 6204 (shown open here but in practice clamped shut to grip the pipeline 6320). Step (b) shows the structure still in use for laying pipe, but inclined to achieve a lay angle of 35 degrees or so off-vertical. To reach this position ram 6304 has contracted a little.

In steps (c) and (d), ram 6304 contracts still further by stages, until the tiltable structure 6202 is fully horizontal and within the fixed structure 6300 which supports the working deck 6136 (not shown). Part of the fixed structure 6300 is shown in Figures 7 (d) to (h), to provide a point of reference for the reader to follow the subsequent movement of the structure 6202 as it retracts inboard from the stern of the vessel.

For steps (e) to (h), the pin connecting arm 6306 to the fixed structure 6300 is now removed, so that the arm is free to pivot now about the second pivot 6308, fixed on deck. This changes the action when the ram 6304 subsequently expands again. Following the sequence of steps (e) to (h) in the drawing, and watching the position of structure 6202 relative to the portion of fixed structure 6300 which is shown for comparison, it will be seen how expansion of ram 6304 now causes the structure 6202 to cant slightly, but also to be displaced horizontally away from the stern of the vessel. At the end of the movement, with ram 6304 fully extended, the structure 6202 is again fully horizontal.

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Of course various modifications of the above examples can be envisaged by the skilled person, without departing from the spirit or scope of the invention in one or more of its aspects. For example, retraction of the movable structure 202/6202 may be unnecessary  
5 in a given situation, or it may be achieved entirely by skidding. Other types of tensioning means may be substituted for the track tensioners shown. Radius controllers may be smooth chutes as shown, and/or may comprise sheaves or tracked arches. Instead of being located at the stern of a vessel, the apparatus may be adapted to launch the product over the side or the bow, or through a "moonpool".



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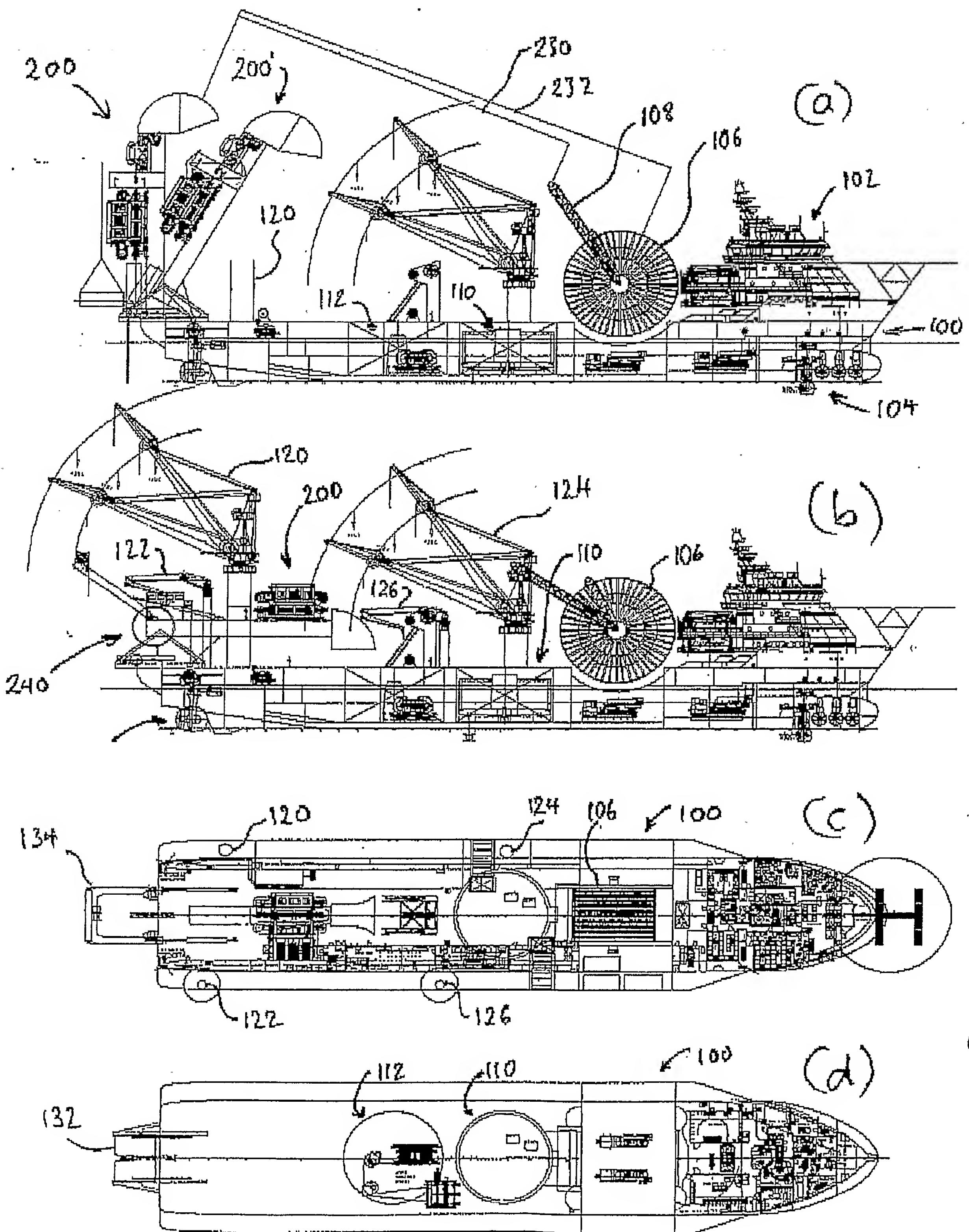


Fig. 1



Fig. 2

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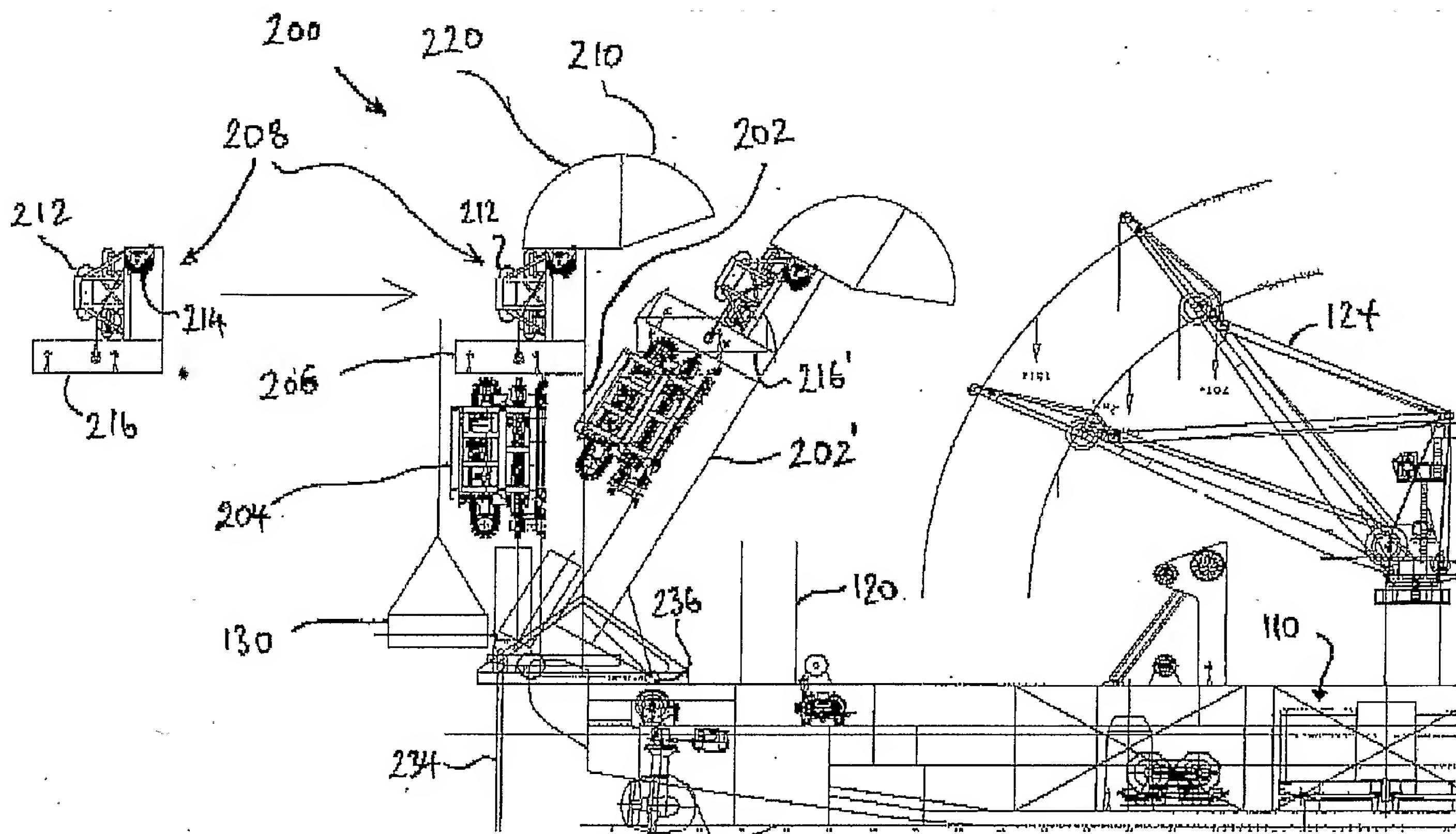
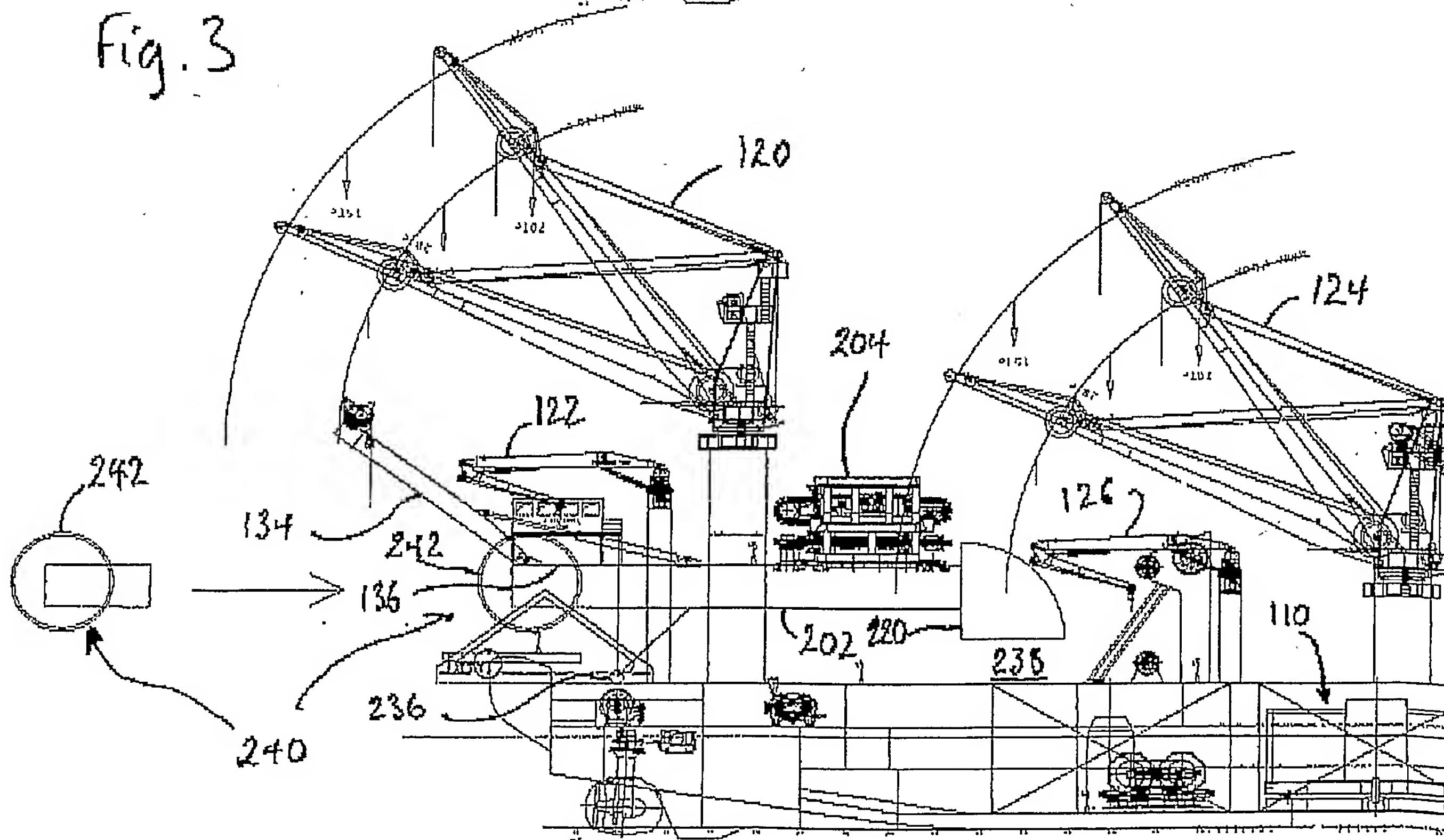


Fig. 3





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Fig. 4

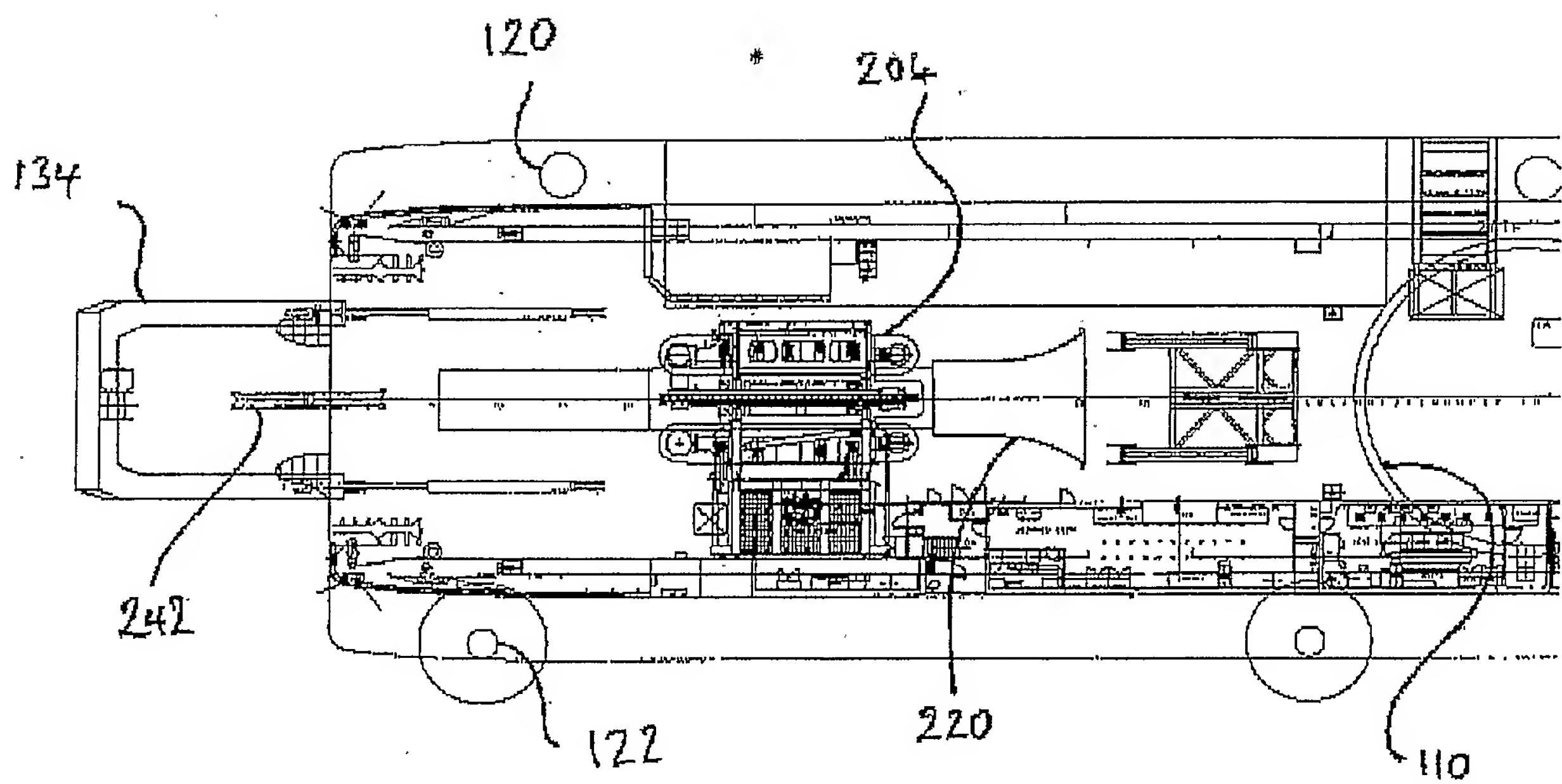
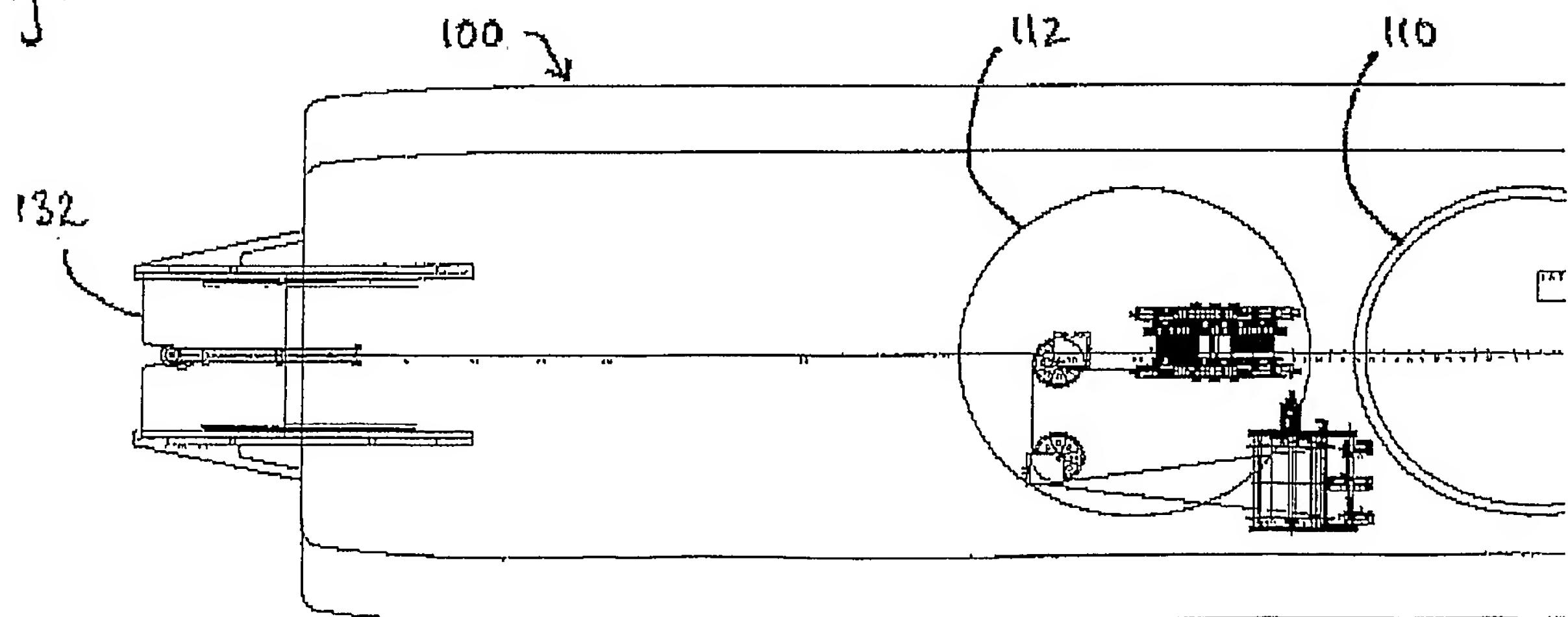


Fig. 5





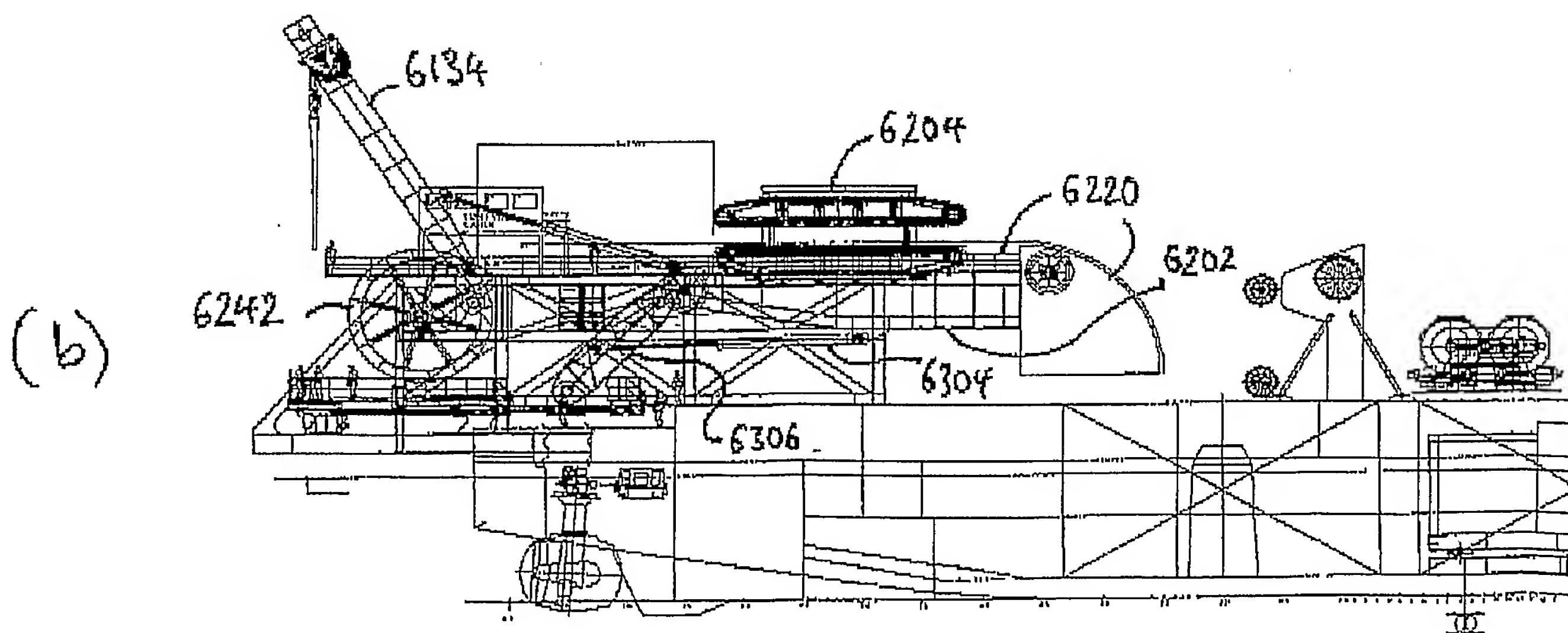
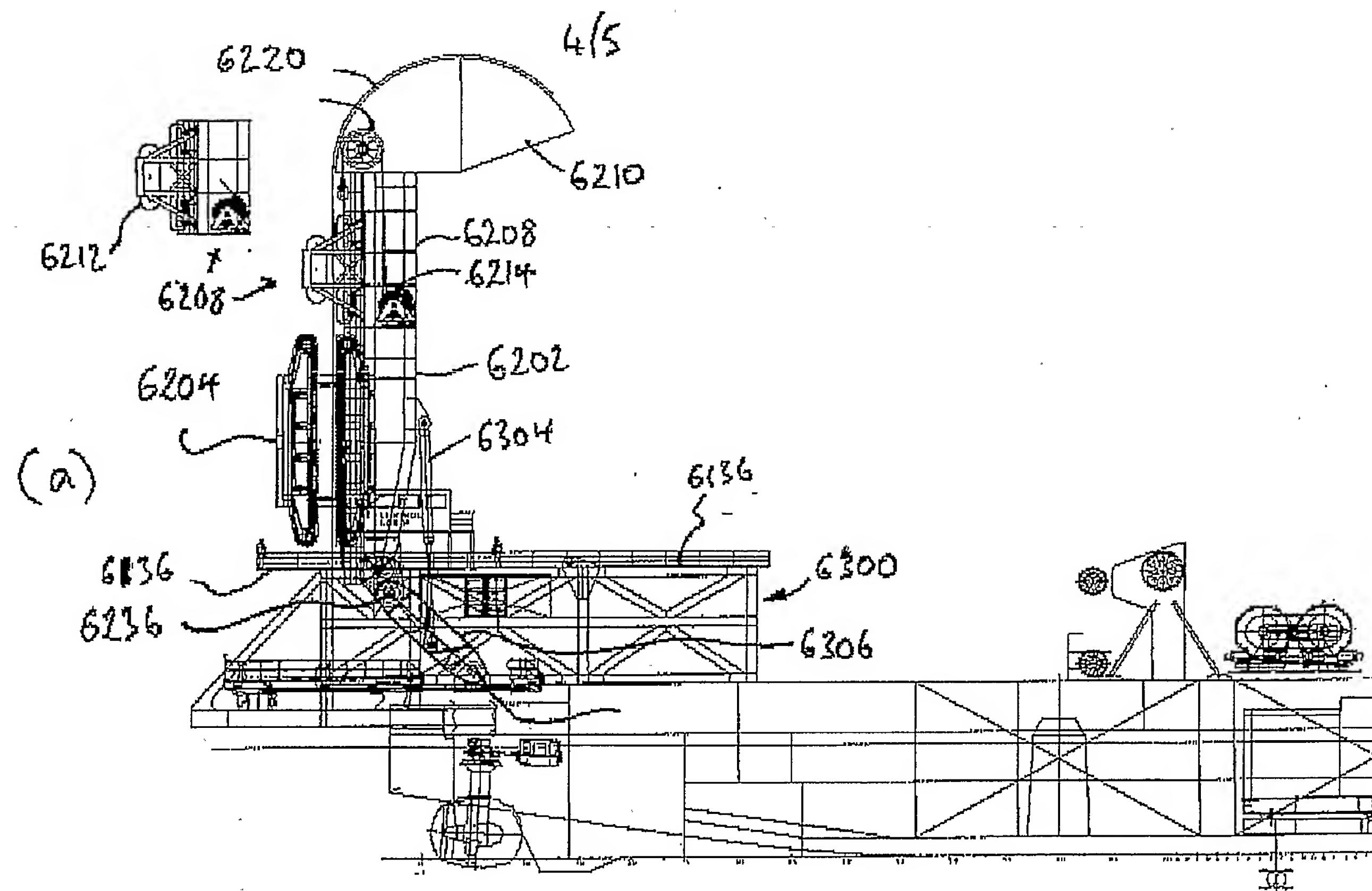


Fig. 6



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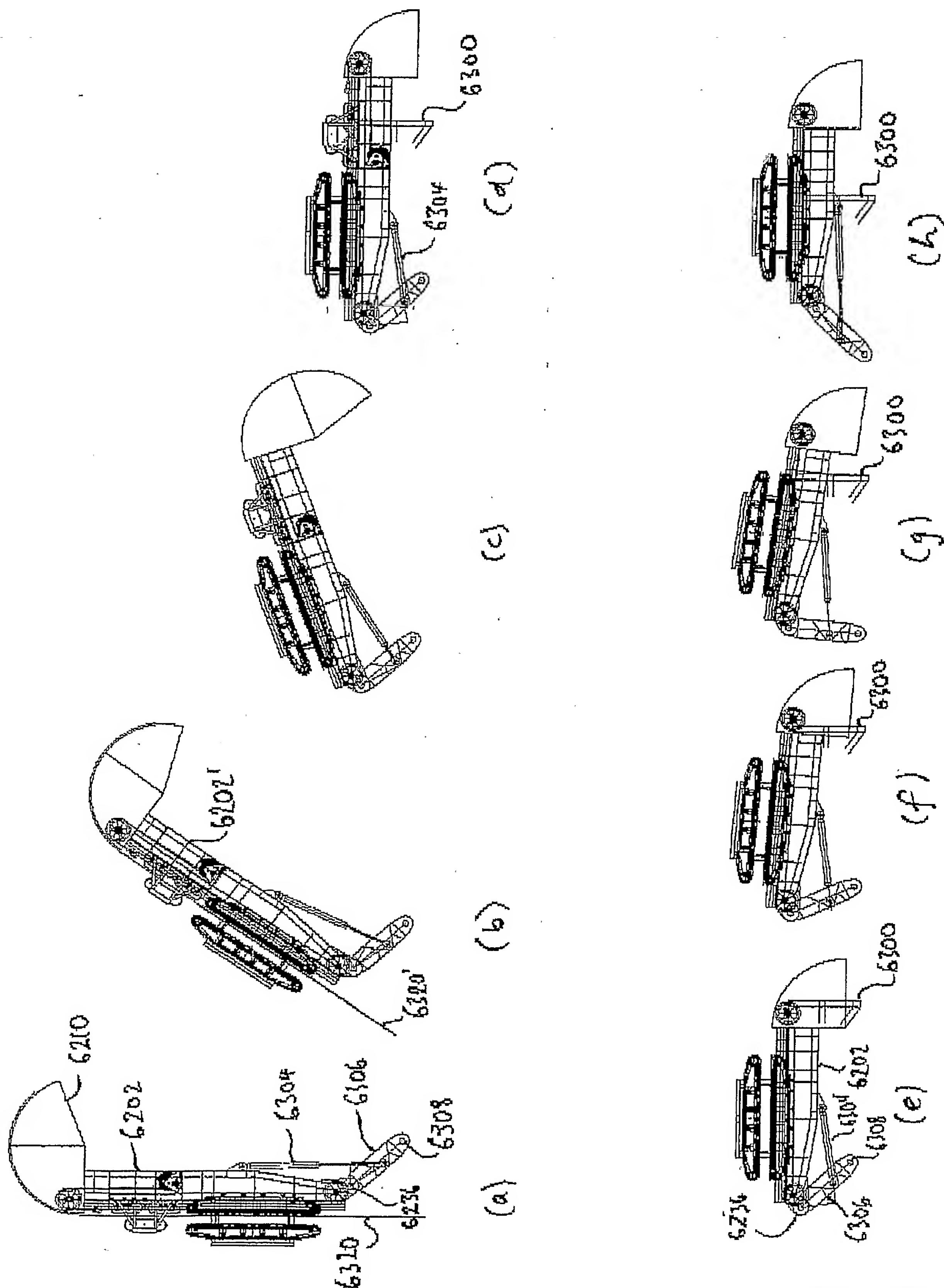


Fig. 7

